Determining coordinates of a workpiece

Description

5   The invention relates to a method and a measuring
arrangement for determining coordinates of a workpiece.

In order, in particular, to be able to acquire dimensions
and shape features of an object, use is made of
10   coordinate measuring devices that scan one or more
surfaces of the object (for example doing so optically
without contact, or by contact scanning of the surface).

So called alternative measuring methods have been
15   proposed, in which a measuring radiation produced by a
radiation source penetrates the material of the object.
For example, US 6,341,153 B1 describes a system for
nondestructive examination of parts, a three-dimensional
computed tomography imaging method being applied. The
20   system has a portable processor with a CAD/CAM program, a
source of X-radiation, a scintillation screen and a
silicon sensor field. The processor includes commands for
producing an appropriate three-dimensional image in a
coordinate system of the CAD/CAM program.
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Particularly in the case of industrial mass production of
workpieces, the requirement for high-precision,
nondestructive measuring techniques that can be
integrated in the fabrication line is increasing.
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In this description, a workpiece is understood as any
type of objects that are machined in a machining process
and/or are produced and/or used in a production process.
For example, the workpiece itself can be machined and/or
35   can be combined with other workpieces during mounting.

The workpiece can also consist of various interconnected parts.

There is, furthermore, an increasing requirement not only
of determining a few selected dimensions of the workpiece
and their position relative to one another, but in any
case of having the possibility of being able to measure
even regions of the workpiece that are difficult to
access. For example, the functional capacity of a
workpiece can depend substantially on precisely observing
the prescribed dimensions and formations in the region of
a cavity.

Although it is true that measuring methods based on a
measuring radiation that penetrates the material of the
workpiece and whose intensity is measured can be used to
obtain information relating to the position of such
cavities, this information is fuzzy with reference to the
coordinates of the material surfaces and any material
transitions.

It is an object of the present invention to specify a
method and a measuring arrangement for determining
coordinates of a workpiece that enable different types of
features of a workpiece to be measured, the aim being to
enable optimization of the measurement outlay and of the
measurement costs. In a particular refinement, the method
or the measuring arrangement is to be suitable in
conjunction with an acceptable economic outlay for
measuring workpieces with hollow regions or ones that are
difficult to access.

A method for determining coordinates of a workpiece is
proposed in which a first coordinate system which is
fixedly positioned with reference to the workpiece is

defined, in which first coordinates of the workpiece are
measured by using a first coordinate measuring device, in
which second coordinates of the workpiece are measured by
using a second coordinate measuring device, and in which

5   a common set of coordinates in the first coordinate
system or in a second coordinate system fixedly
positioned with reference to the workpiece is generated
from the first coordinates and from the second
coordinates.

10

In particular, coordinates of a multiplicity of the
workpieces can be determined during and/or after a
production process and/or machining process of the
workpieces.

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It is possible by using various coordinate measuring
devices to measure various types of features of the
workpiece, to measure features of the workpiece with a
different speed and/or accuracy, and/or to measure

20 features that have been newly added during a production
process of the workpiece solely with the aid of one of
the coordinate measuring devices. More possibilities
exist by comparison with measurement with the aid of only
one coordinate measuring device. By dividing the features

25 of the workpiece that are to be measured into features
that are measured with the aid of the first and with the
second coordinate measuring device, it is possible to
optimize with regard to measurement costs, measuring
precision and/or measuring speed.

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It is preferred to apply different measurement principles
for measuring the coordinates in the first coordinate
measuring device and in a second coordinate measuring
device. In particular, various classical measurement

principles such as, for example, tactile scanning of
surfaces, are taken into consideration.

For example, one of the coordinate measuring devices is a
5   device with a probe that scans the workpiece while making
contact with a surface and in this way determines the
coordinates. Devices can also be used which scan the
surface of the workpiece without making contact (for
example, optical scanning of surfaces, in particular by
10   means of the so called stripe or grating projection).

It is preferred to make use as the other one of the
coordinate measuring devices of a device that determines
information relating to the workpiece by using radiation
15   that penetrates the material of the workpiece and is
attenuated and/or deflected in the process. Examples of
this are computed tomography devices based on X-
radiation, electron radiation and/or positron radiation.
With such systems, in particular, the outer and inner
20   contours of the workpiece are acquired in a fuzzy
fashion, a transition from low gray scale values to high
gray scale values, for example, representing a surface or
edge of the workpiece. Again, the type of fuzziness that
is determined, in particular, by the extinction and the
25   diffraction of radiation is a function of the material of
the workpiece. The invention is, however, not restricted
to the use of such devices as the other coordinate
measuring device. However, it is also possible, for
example, to use devices which scan the surface of the
30   workpiece without making contact and, for example,
optically scan surfaces of the workpiece (in particular
by means of the so called stripe or grating projection).

In a more general formulation, it is preferred to make
35   use of a first coordinate measuring device that supplies

more precise (first) coordinates of the contours acquired
by it, and the second coordinates determined by the
second coordinate measuring device are referred to a
coordinate system fixedly positioned with reference to
5   the workpiece by using the first coordinates. In
particular, it is possible to make use to this end of a
spacing of measuring points that is determined from the
first coordinates (for example a length or a diameter of
the workpiece). When the spacing has been fixed, it is
10   possible, for example, to determine from the spacing of
gray scale values of equal intensity at various fuzzy
contours where the contours of the workpiece must be
located. It is preferred to make use not only of one
dimension for scaling and/or positioning of the
15   information determined from the second coordinate
measuring device, but of at least two dimensions. In this
case, the dimension can include redundant and/or
nonredundant information and/or can be oriented in
various and/or identical directions. A redundancy
20   increases the reliability of the scaling and/or
positioning, while nonredundant dimensions can be used to
scale and/or position in different directions.

In an even more general formulation, it is proposed that
25   measured values of the workpiece (or of a reference
object) are measured by the second coordinate measuring
device in a spatial region in which an edge or material
transition of the workpiece (or of the reference object)
is located, the first coordinates measured by the first
30   coordinate measuring device being used for the purpose of
assigning a position of the edge or of the material
transition and the measured values to one another. In the
case of the measurement of a reference object, the first
coordinates also relate to the reference object.

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The designation "first" coordinate measuring device is
not to be understood as meaning that the measurement
carried by it or measurements carried out by it takes or
take place before the measurement or the measurements of
5   the second coordinate measuring device. On the contrary,
the measurements can be carried out in any desired
sequence, simultaneously and/or repeatedly. Again, one or
more further coordinate measuring devices can be
provided. In practice, the time of the measurements can
10   depend on how the measurements are best to be integrated
in a production line and/or an assembly line.

The invention can relate, in particular, to the case when
the workpiece is brought during the measurements into a
15   changed position with the aid of the two coordinate
measuring devices. In this case, the workpiece is moved,
for example, from one to the other measuring device,
and/or its position is changed such that additional
measurement information is available.
20

In addition, it is possible or, in some circumstances
even necessary (for example in the case of coordinate
measuring devices with radiation that penetrates the
workpiece) for the workpiece also to be moved during the
25   measurement (for example in order to obtain coordinates
in a three-dimensional coordinate system).

The first coordinates and/or the second coordinates can
be measured in a reference coordinate system or,
30   respectively, in a reference coordinate system.

In one refinement of the invention, the workpiece and at
least one reference object are fixedly interconnected,
reference coordinates of the reference object(s) being
35   measured by the first coordinate measuring device and by

the second coordinate measuring device, and the common
set of coordinates being generated by using the reference
coordinates. It is possible here for the first and the
second coordinate measuring devices to use different
5   reference coordinate systems with respect to which the
first and, respectively, second coordinates are measured.
For example, this is sensible whenever the workpiece is
being measured by one coordinate measuring device in a
measuring position in which the reference object(s)
10   cannot be measured in the same way as it/they can be
measured by the other coordinate measuring device. In
this case, the coordinate measuring devices can refer,
for example, to different reference objects or different
features of the same reference object in order to
15   determine the reference coordinate system. However, it is
preferred for the coordinate measuring devices to refer
to the same reference coordinate system, and for the
workpiece coordinates to be measured in this coordinate
system. This refinement simplifies the production of the
20   common set of coordinates in the coordinate system fixed
in the workpiece.

The reference object(s) is/are or will be connected
directly and/or indirectly to the workpiece.
25

In particular, coordinates of the workpiece and reference
coordinates of the reference object(s) can be measured by
the first coordinate measuring device, by the second
coordinate measuring device or by a further coordinate
30   measuring device, information relating to a relative
position and orientation of the reference object(s) on
the one hand, and of the workpiece on the other hand
being obtained, and the common set of coordinates being
generated by using the information relating to the
35   relative position and orientation. In the event of an

unchanged relative position and orientation, an absolute
orientation and/or position of the reference object(s)
with the workpiece fastened thereon can then be varied
between the measurement of the first coordinates and the

5   measurement of the second coordinates. For example, in
order to obtain information relating to the relative
position and orientation, on the one hand, coordinates of
at least one characteristic shape feature of the
workpiece are measured in a coordinate system that is

10   fixed with reference to the respective coordinate
measuring device, and on the other hand coordinates of
the reference object(s) are measured in the same
coordinate system.

15   The reference object(s) can be any desired suitable
objects. Balls are particularly suitable since these can
be acquired reliably and precisely (scanned or acquired
in another way) from various directions and by various
coordinate measuring devices.

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In a preferred refinement, which is examined in more
detail below with reference to the attached figures, the
workpiece is fastened on a pallet during the measurements
carried out by the coordinate measuring devices. The

25   pallet has, for example, a dimensionally stable plate on
which the workpiece is arranged. Such a plate has the
advantage that the workpiece is covered solely on one
side. The reference object(s) can, in turn, be fastened
on the pallet. The pallet with the workpiece attached

30   thereon can, for example, be moved or transported from
one measuring station to another measuring station, and
can be aligned as desired in the measuring stations. As
an alternative to the pallet, it is possible to fasten on
the workpiece another object that is the at least one

35   reference object, or on which the at least one reference

object is or will be arranged. If at least one of the measuring devices uses a measuring radiation that transirradiates the material of the workpiece, it is preferred to select for the pallet a material that has a

5   small absorption coefficient for the measuring radiation.

In order, in particular, to reduce the outlay when determining the reference coordinate system in the case of serial measurement of workpieces, the reference

10   object(s) with the workpiece fastened thereon is/are moved into a defined position which is fixed with respect to the first coordinate measuring device and/or to a second coordinate measuring device. At least some of the reference coordinates, the first coordinates and/or the

15   second coordinates are measured, while the reference object(s) is/are located in the defined position. The position of the reference coordinate system is also known from the defined position. If a number of reference objects or shape features of a reference object are

20   located simultaneously in a defined position in each case, an orientation of the reference coordinate system is also known in addition.

The scope of the invention also includes a measuring

25   arrangement for determining coordinates of a workpiece, in which the measuring arrangement exhibits the following:
          - a first coordinate measuring device for measuring first coordinates of the workpiece,

30   - a second coordinate measuring device for measuring second coordinates of the workpiece, and
          - a determining device that is connected to the first and the second coordinate measuring device

35   and is fashioned for generating a common set of

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coordinates for the workpiece from the first coordinates and from the second coordinates, the common set of coordinates being defined in a coordinate system that is fixedly positioned with reference to the workpiece.

In particular, the measuring arrangement can have a movement device (for example a conveyor belt and/or a roller conveyor) that is fashioned for bringing the workpiece into a measuring position in which the first coordinate measuring device and/or the second coordinate measuring device can measure the first or, respectively, the second coordinates of the workpiece. This movement device can be fashioned, in particular, for bringing a multiplicity of the workpieces into the measuring position one after another.

Further included in the scope of the invention are:

- a computer program with program code means that when running on a computer or computer network execute at least that part or those parts of the inventive method in one of its refinements, which part or parts relates or relate to controlling at least one of the measuring devices and/or to processing the measurement information obtained by the measurements. In particular, the program code means can be stored in the form of a computer readable data carrier;

- the data carrier with the stored program code means; and

- a corresponding computer program product. In this case, a computer program product is understood as

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the program or the program code means as
commercial product. It can fundamentally be
present in any desired form, for example on paper
or a computer readable data carrier, and can, in
5   particular, be distributed over a data
transmission network.

The invention is explained in more detail below with the
aid of exemplary embodiments that are represented
10   schematically in the figures. However, the invention is
not restricted to the examples. Identical reference
numerals in the individual figures in this case denote
identical or functionally identical elements, or elements
corresponding to one another with regard to their
15   functions. In detail:

figure 1   shows a schematic of a coordinate measuring
             arrangement having two coordinate measuring
             devices;

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figure 2   shows a side view of a conveyor device for
             conveying a plurality of workpieces one after
             another to a measuring station in which
             coordinates of the workpiece are measured;

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figure 3   shows a view from above on to the conveyor
             device in accordance with figure 2, the
             workpiece being transirradiated in the
             measuring station by a measuring radiation of a
30   coordinate measuring device;

figure 4   shows a view from above on to a further
             conveyor device that conveys the workpieces to
             a second measuring station in which the

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workpieces are scanned by a coordinate
measuring device of portal design;

figure 5   shows the measuring station in accordance with
            figure 4, in a side view;

figure 6   shows an illustration of the principle of a
            coordinate measuring device that
            transirradiates a workpiece that has a cutout;

figure 7   shows a profile of measured values that were
            measured by the coordinate measuring device
            shown in figure 6, along a coordinate axis;

figure 8   shows a flowchart that illustrates the
            particularly preferred embodiment of a method
            for determining workpiece coordinates; and

figure 9   shows a diagram that illustrates an aspect of
            the determination of a common set of
            coordinates from measurements of two coordinate
            measuring devices.

The measuring arrangement 1, illustrated in figure 1, for
determining workpiece coordinates has a first coordinate
measuring device 3 and a second coordinate measuring
device 5. The figure shows a workpiece 9 with a plurality
of shape features that are denoted by the reference
numeral 10. The workpiece 9 is fastened in this example
on a pallet-type carrier 7, for example, clamped, bolted
down and/or adhesively bonded. Likewise fastened on the
carrier 7 are three mutually spaced apart reference
objects 8a, 8b, 8c that are respectively arranged in the
region of a corner of a rectangular surface of the
carrier 7. It is indicated at one (8b) of the reference

objects with the aid of three arrows that the three
reference objects define a coordinate system that is
fixedly positioned with reference to the carrier 7. This
coordinate system is denoted in the further description
5   as reference coordinate system and abbreviated as RCS.
The reference objects 8 are, for example, balls.

Likewise indicated by three arrows is a coordinate system
WCS belonging to a workpiece. Because the workpiece 9 is
10 fastened on the carrier 7, the RCS and the WCS remain in
approximately unaltered relative position and relative
orientation to one another. It is therefore possible to
measure coordinates of the workpiece 9 by means of the
various coordinate measuring devices 3, 5 (and, possibly,
15 by means of further coordinate measuring devices) in the
RCS, and to convert them into the WCS at a desired point
in time.

On the basis of a possible variation in the temperature
20 that can take place during a measurement by means of one
of the coordinate measuring devices 3, 5, and/or between
measurements by means of various ones of the coordinate
measuring devices 3, 5, variations in the relative
position and the scalings of the RCS and the WCS can
25 occur. It is therefore proposed to measure the
temperature and to calculate the variation by taking
account of the coefficients of thermal expansion of the
materials of the carrier 7 and of the workpiece 9. It is
preferred to integrate a temperature sensor in the
30 carrier 7 for the purpose of measuring the temperature.

The measurement of the coordinates of the workpiece 9 is
indicated by arrows in the illustration of figure 1, the
first coordinate measuring device 3 and the second
35 coordinate measuring device 5 measuring coordinates of

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the same workpiece 9 simultaneously and/or one after
another.

The corresponding measured data can, for example, be
5   transmitted from the first coordinate measuring device 3
to a data processing device 11 that calculates the
relative position and orientation of the RCS and the WCS
and transmits this information to the second coordinate
measuring device 5. Alternatively or in addition, the
10   data processing device 11 can assume further ones of the
functions described in this description, for example the
conversion of the coordinates determined by the
coordinate measuring devices 3, 5 into the WCS and/or the
temperature correction.
15

Figure 2 shows in combination with figure 3 to figure 5 a
particularly preferred embodiment of the coordinate
measuring arrangement according to the invention. The
measuring arrangement has a conveyor device 12 on which a
20   plurality of workpieces 9 are arranged. The workpieces 9
can be, for example, the workpieces 9 illustrated in
figure 1, which are fitted on a pallet 7 with reference
objects 8 fastened thereon. The conveyor device 12
conveys a multiplicity of the workpieces 9 one after
25   another to a first measuring station 14, of which only a
stop 13 is illustrated in figure 2. Somewhat later than
the instantaneous picture illustrated in figure 2, one of
the workpieces 9 reaches the stop 13 and thus a defined
position on the conveyor path. In this position, the
30   workpiece 9 is transirradiated with X-radiation from a
radiation source 17 or measured optically. A sensor
device 16, arranged downstream of the workpiece 9 from
the point of view of the radiation source 17, for taking
a two-dimensional image of the incident X-radiation
35   serves the purpose of acquiring information produced on

the basis of the attenuation and diffraction of the X-
radiation by the workpiece 9. For example, by virtue of
the fact that the radiation source 17 is brought into at
least one other position from which the X-radiation can
5   reach the workpiece 9 from another direction, further X-
ray images are taken and a three-dimensional X-ray image
of the workpiece 9 is produced by a data processing
system (not shown in figure 3). The measuring station 14
is constructed in such a way that the reference objects 8
10   arranged on the pallet 7 are also included in the X-ray
images.

Figure 4 shows a further conveyor device 12 of the
measuring arrangement on which the same workpieces 9 as
15   of the conveyor device shown in figure 3 are being
conveyed either previously or subsequently to a second
measuring station 15. The second measuring station 15 has
a measuring table 21 that is arranged spaced apart from
the conveyor device 12. From the conveyor device 12 shown
20   in figure 4, the workpiece 9 passes, for example, through
a movable gripper onto the measuring table 21. As may be
seen from figure 5, the measuring station 15 is a
coordinate measuring device 20 of portal design. Two
uprights 22, 23 of the coordinate measuring device 20
25   that are mounted capable of longitudinal displacement in
a horizontal direction support a transverse guide 24 by
which a quill 25 is mounted in a fashion capable of
transverse movement. The quill 25 and a probe 26 fastened
on its lower end can move in a vertical direction such
30   that the probe 26 can reach the desired positions within
a measuring range of the coordinate measuring device 20.

In order to measure the coordinates of the workpiece 9,
the probe 26 scans the workpiece 9 and the reference
35   objects 8 on the pallet 7 while in contact with the

respective surfaces, and three-dimensional coordinates of the workpiece 9 are picked up in a coordinate system defined by the reference objects 8. As is described in yet more detail with reference to figure 8 and figure 9,

5   it is thereby possible to produce a common set of coordinates in a coordinate system belonging to the workpiece from the coordinates of the workpiece 9 determined in the second measuring station 15. It is further possible, as explained in yet more detail with

10   reference to figures 6 and figure 7, to determine the orientation of contours of the workpiece 9 that have been fuzzily picked up in the first measuring station with the accuracy that can be achieved in the second measuring station.

15

Figure 6 shows a radiation source 17 for producing X-radiation (or another radiation that is suitable for penetrating the material of a workpiece 9), a workpiece 9 and a sensor device for taking a two-dimensional image of

20   the impinging radiation. As is indicated by an axis of rotation 18, the workpiece 9 can be rotated, and it is thereby possible to take a multiplicity of two-dimensional images from various viewing angles such that a three-dimensional image of the workpiece 9 can be

25   determined by computation.

The workpiece 9 has a deep and narrow cutout whose surface coordinates cannot be measured or can be measured only in a restricted fashion with coordinate measuring

30   devices that scan the surfaces. It is therefore proposed to combine a measuring device of the type that is illustrated in figure 6 with a further measuring device, which scans the surface, and to calculate the desired coordinates of the workpiece from measurements with both

35   measuring devices.

Figure 7 shows results of a three-dimensional spatial
radiation absorption field (doing so only in one
dimension for reasons of clarity and ease of
5   illustration) that has been calculated from a
multiplicity of two-dimensional images of the measuring
arrangement shown in figure 6. The radiation absorption
field corresponds to the radiation absorption effected by
the workpiece 9 at the respective point in the three-
10 dimensional space. The absorption I of a workpiece region
in the x-direction that has a length L is illustrated in
the diagram of figure 7. In other words: the material
surfaces of the workpiece region lie at a distance of
length L from one another in the x-direction. Located
15 between the material surfaces is a material of the
workpiece that is homogeneous with regard to the
radiation absorption.

As is to be seen from the schematic in figure 7, the
20 measured absorption at the material surfaces does not
increase or decrease in steps. Rather, the material
surfaces are detected only fuzzily by the absorption
measurement. There is a fuzziness of breadth D in the x-
direction. The actual position of the material surfaces
25 in the x-direction can be determined if the length L is
known. For example, it can be assumed for this purpose
that the two material surfaces opposite one another have
equally fuzzy absorption profiles. In this case, the
position of the material surfaces is yielded from the
30 spacing between two absorption values of equal magnitude,
the spacing being equal to the length L. The length L is
determined, for example, from an exact measurement by a
coordinate measuring device that scans the material
surfaces. The entire procedure can be denoted as
35 calibration. Alternatively or in addition, the

calibration can be carried out with the aid of at least
one reference object, for example on material surfaces of
the balls 8 fastened on the pallet 7.

5   A particularly preferred embodiment of the method
according to the invention will now be described with the
aid of the flowchart of figure 8.

As a start, a workpiece is fixedly connected to a
10   plurality of reference objects in a step S0, and in a
following step S1 is brought into a first measuring
position in which a first coordinate measuring device can
measure coordinates of the workpiece and of the reference
object. Instead of a plurality of reference objects, it
15   is also possible for a single reference object to be
fixedly connected to the workpiece, the reference object
having features that can be acquired by a coordinate
measuring device (for example shape features and/or
optically detectable features) which enable the
20   coordinate measuring device to determine a coordinate
system defined by the reference object.

In a following step S2, the workpiece and the reference
object are measured by the first coordinate measuring
25   device, and the relative position and orientation of a
reference coordinate system RCS defined by the reference
objects, on the one hand, and a coordinate system WCS
belonging to the workpiece, on the other hand, are
determined. The information relating to the relative
30   position and orientation of the RCS and the WCS are
stored in a subsequent step S7. The determination of the
relative position and orientation can take place
alternatively or in addition at a later instant and, in
particular, can be carried out by a second coordinate
35   measuring device.

In a step S3 following the step S2, the first coordinate
measuring device measures first coordinates of the
workpiece in the RCS. If the determination of the
5   relative position and orientation of the RCS and the WCS
has already taken place, and if the position of the RCS
relative to the first coordinate measuring device has not
changed since then, the first coordinates can be measured
and/or stored directly in the WCS.
10

There now follows an optional step S4 in which the
workpiece with the reference objects (or the reference
object) fastened thereon are/is brought into a changed
orientation and/or position. Before the next step S5, the
15   workpiece is brought in any case into an orientation and
position so that at least coordinates of a part of the
workpiece can be measured by a second coordinate
measuring device. Furthermore, the second coordinate
measuring device must be capable in this orientation and
20   position of determining the RCS itself (that is to say of
producing the reference to its own coordinate system), or
determining at least one further, second RCS. Coordinates
that are present in various ones of the reference
coordinate systems can be converted into a common
25   coordinate system by means of information relating to the
reference objects or the reference object.

In particular, two or more different RCS can be
determined by one of the coordinate measuring devices,
30   and in each case the corresponding relative positions and
orientations of the RCS and of the WCS can be determined.
This is advantageous, in particular, whenever the same
features of the reference object(s) is/are not accessible
to the other coordinate measuring device, and therefore a
35   specific RCS cannot be examined by it.

In the following step S5, the second coordinate measuring
device determines the RCS (or the second RCS). As an
option, before or after the execution of the following
5   step S6 the second coordinate measuring device is fed the
information determined by the first coordinate measuring
device and relating to the relative position and
orientation of the RCS and of the WCS. In step S6, the
second coordinate measuring device now measures second
10   coordinates of the workpiece. Steps S5 and S6 can also be
interchanged. If the information relating to the relative
position and orientation of the RCS and the WCS is
already available before the second coordinates are
measured, the second coordinates can be measured and/or
15   stored directly in the WCS.

In a concluding step S8, a common set of coordinates is
now generated from the first coordinates and from the
second coordinates, specifically in a coordinate system
20   that has been fixed with reference to the workpiece. In
particular, in this step the first and second coordinates
measured respectively in the RCS or in one of the RCS can
be converted into the WCS - by using the information
relating to the relative position and orientation of the
25   workpiece and of the reference object(s). Furthermore, it
is possible in this case for the above-described
calibration to be carried out if required.

It is now to be further explained with reference to
30   figure 9 how the information relating to the orientation
and position of the reference coordinate system(s)
relative to the workpiece ("the relative information"
below) can be used. The steps illustrated in figure 9 can
also respectively be a device implemented as hardware
35   and/or software. Step S11 corresponds in this case to a

device for determining the relative information, step S12
corresponds to an evaluation device that executes step S8
of figure 8, for example, step S14 corresponds to a data
processor of a first coordinate measuring device and step

5   S13 corresponds to a data processor of a second
coordinate measuring device.

In accordance with an exemplary embodiment indicated by
solid lines in figure 9, the second and the first

10 coordinates, respectively, of the workpiece in the or one
of the reference coordinate systems are determined in
step S13 and step S14. Furthermore, the relative
information is determined in step S11. The steps S11, S13
and S14 can be carried out in any desired temporal

15 sequence and/or simultaneously. Again, at least one
further coordinate measuring device can be provided that
measures third or further coordinates of the workpiece,
and/or that carries out the measurements required for
determining the relative information. The measured

20 coordinates of the workpiece are processed in step S12 by
using the relative information, in order to generate the
common set of coordinates.

As indicated by the broken lines in figure 9, the

25 relative information can be determined from measured
coordinates of the first and/or second coordinate
measuring device(s). If the measured coordinates (of the
workpiece and of the reference object(s)) include the
corresponding information that forms the basis of the

30 relative information, this means that the respective
coordinate measuring device can measure the coordinates
both in the reference coordinate system and in the
coordinate system belonging to the workpiece (or in the
coordinate system of the coordinate measuring device) or

35 can convert them into one of the coordinate systems.

Finally, a central evaluation of the measured coordinates is not mandatory for determining the common set of coordinates. Rather, it is possible, for example, for one of the coordinate measuring devices to take over this
5   function.